

GAO

Report to the Chairman, Legislation
and National Security Subcommittee,
Committee on Government Operations,
House of Representatives

March 1991

STRATEGIC DEFENSE INITIATIVE

Need to Examine Concurrency in Development of Brilliant Pebbles





United States
General Accounting Office
Washington, D.C. 20548

National Security and
International Affairs Division

B-223094

March 27, 1991

The Honorable John Conyers, Jr.
Chairman, Legislation and National
Security Subcommittee
Committee on Government Operations
House of Representatives

Dear Mr. Chairman:

This report is an unclassified version of the classified report we provided you in November 1990 in response to your request that we review the Strategic Defense Initiative Organization's program for developing Brilliant Pebbles, the space-based weapon system for the Phase I Strategic Defense System.

Since our classified report, the Department of Defense has made significant changes to concurrency and schedule issues relating to the Brilliant Pebbles program. In February 1991 the Strategic Defense Initiative Organization said that the Brilliant Pebbles acquisition strategy has been revised to reduce schedule concurrency significantly in the program. The revised schedule extends the pre-full-scale development phase from 30 to 50 months, delays a full-scale development decision from the summer of 1993 until fiscal year 1995, reduces Livermore's flight experiments by half, and moves a deployment decision to the late 1990s. Consequently, the matter for congressional consideration in our classified report may no longer be relevant.

As arranged with your office, unless you publicly announce its contents earlier, we plan no further distribution of this report until 30 days after its issue date. At that time we will send copies to appropriate congressional committees, the Secretaries of Defense and the Air Force, and the Directors of the Strategic Defense Initiative Organization and the Office of Management and Budget. We will also make copies available to others.

Please contact me at (202) 275-4268 if you or your staff have any questions concerning this report.

Sincerely yours,

A handwritten signature in black ink that reads "Nancy R. Kingsbury". The signature is written in a cursive style with a large, stylized 'N' and 'K'.

Nancy R. Kingsbury
Director
Air Force Issues

Unclassified Version of November 1990 Report

GAO

United States
General Accounting Office
Washington, D.C. 20548

National Security and
International Affairs Division

B-223094

November 19, 1990

The Honorable John Conyers, Jr.
Chairman, Legislation and National
Security Subcommittee
Committee on Government Operations
House of Representatives

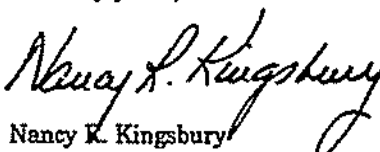
Dear Mr. Chairman:

This report responds to your request that we review the Strategic Defense Initiative Organization's program for developing Brilliant Pebbles, the space-based weapon system for the Phase I Strategic Defense System. The report suggests that the Congress consider whether the concurrency in the program is justified by the President's need to make a decision by the summer of 1993 on whether to begin full-scale development and deployment.

As arranged with your office, unless you publicly announce its contents earlier, we plan no further distribution of this report until 30 days after its issue date. At that time we will send copies to appropriate congressional committees; the Secretaries of Defense and the Air Force; the Directors, Strategic Defense Initiative Organization and Office of Management and Budget; and other interested parties with appropriate security clearances.

Please contact me at (202) 275-4268 if you or your staff have any questions concerning this report. Major contributors to this report are listed in appendix I.

Sincerely yours,



Nancy R. Kingsbury
Director
Air Force Issues

EXECUTIVE SUMMARY

PURPOSE

In 1989 the President directed the Department of Defense to provide sufficient information so that he could make an informed decision within 4 years on deployment of strategic defenses. He specified that particular emphasis should be given to Brilliant Pebbles, a space-based weapon system concept developed at Lawrence Livermore National Laboratory. In the summer of 1989, the Strategic Defense Initiative Organization (SDIO) initiated studies to identify the best space-based weapon concept, and in February 1990 it announced that Brilliant Pebbles was replacing the Space-Based Interceptor, one of several elements in the Phase I Strategic Defense System, which has been in development since 1987.

The Chairman, Legislation and National Security Subcommittee, House Committee on Government Operations, requested that GAO review the status, schedule, and cost of the Brilliant Pebbles Program.

BACKGROUND

The Brilliant Pebbles concept consists of several thousand interceptors orbiting the earth with the capability to detect and destroy targets by smashing into them at high speed. Each interceptor will be housed in a lifejacket that will provide, among other things, communications and the necessary on-orbit protection.

SDIO has established two concurrent Brilliant Pebbles research and development programs to enable the President to make a decision not later than the summer of 1993 on deployment of strategic defenses. Both programs are part of the demonstration and validation phase, which precedes full-scale development.

One program, involving Livermore's design and test vehicles, consists of a series of flight and underground tests to demonstrate that Brilliant Pebbles technology can intercept ballistic missiles and survive in wartime conditions. The flight test portion of this program began in fiscal year 1990 and is scheduled to be completed in February 1993.

The other program, involving system contractors, began in June 1990 and is scheduled to be completed in June 1993. During the first 8 months of the program, six competing system contractor teams will be preparing proposals to improve Livermore's Brilliant Pebbles design concept. SDIO refers to this part of the program as "concept definition." During the remainder of the program, two of the six contractor teams will develop and test their versions of Brilliant Pebbles. SDIO refers to this part of the program as "pre-full-scale development."

RESULTS IN BRIEF

SDIO's pre-full-scale development program is highly concurrent with Livermore's test program. As a result, SDIO will be paying contractors to improve a design concept before Livermore has fully demonstrated that the concept will work.

A primary objective of Livermore's test program is to demonstrate the technical feasibility of the Brilliant Pebbles concept before a full-scale development and deployment decision is made. However, it is unlikely that Livermore's test program will be completed by the summer of 1993 because it is compressed, providing minimal time to accommodate future problems that are almost sure to occur. The test program has already slipped by 10 months, and the first flight test did not achieve all of its objectives.

Since SDIO substituted Brilliant Pebbles for the Space-Based Interceptor, the cost estimate for the Phase I Strategic Defense System has been reduced by \$13.8 billion, from \$69.1 billion to \$55.3 billion.

PRINCIPAL FINDINGS

The President Directed the Department of Defense to Provide the Basis for a Deployment Decision Not Later Than the Summer of 1993

In 1989 the President directed the Secretary of Defense to conduct research on strategic defenses in a manner that would provide, by the summer of 1993, the basis for an informed decision on deployment of strategic defenses. GAO requested a meeting with the National Security Council to obtain more information about the reasons that led to establishing the decision date. However, the National Security Council referred GAO's request to the Department of Justice because of potential legal issues and stated that it would respond after receiving advice from the Department of Justice. GAO had not heard from the National Security Council at the time its review was completed.

Livermore's Test Program Is Not Likely to Be Completed by the Summer of 1993

SDIO established an ambitious test program schedule for Brilliant Pebbles to support the President's decision. Problems occurring before the first flight test resulted in a 10-month slippage of the test schedule. Moreover, the first flight test did not achieve all its objectives, which has caused the date of the second and third tests to slip again. GAO believes the test schedule will continue to slip because it is compressed, assumes that no problems or failures that cause delays will occur, and is highly dependent on adequate and timely funding. If the end of the test program

slips another 4 months, it will not be completed by the summer of 1993. SDIO's primary objective for Livermore's test program is to prove the technical feasibility of the Brilliant Pebbles concept before the President's decision. SDIO's test plan states it is imperative to demonstrate the concept's technical feasibility as soon as possible to enable national authorities to make informed decisions about entering into full-scale development based on technical and operational merit.

SDIO has directed Livermore to execute increasingly complex flight tests on a compressed schedule. Livermore program officials said that each phase is currently scheduled at the earliest possible start date.

Livermore's schedule is success-oriented; that is, tests have been scheduled at intervals that are achievable in most cases only if the preceding tests occur as scheduled and are successful. However, the flight test program is experimental, and, as a result, some problems are anticipated.

Livermore program officials stated that funding allocations in fiscal years 1989 and 1990 were too low to support the original test schedule. The current schedule continues to be highly dependent on funding.

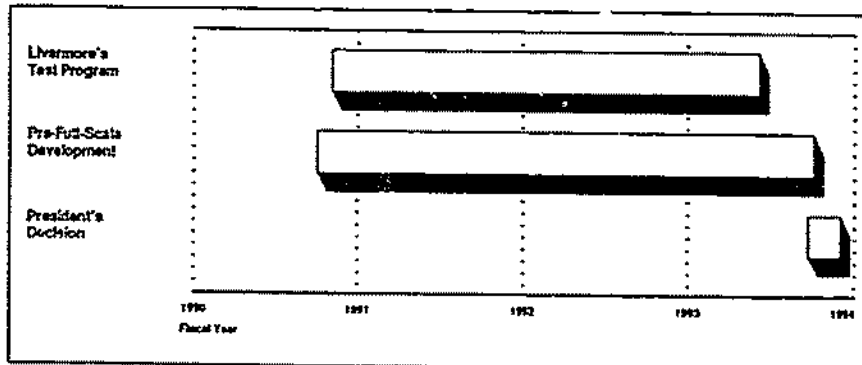
SDIO officials agreed that the schedule is ambitious and success-oriented. They said that SDIO might be able to cancel some of the tests, since some are redundant.

Pre-Full-Scale Development Is Concurrent
With Livermore's Test Program

SDIO's objective for pre-full-scale development is to involve contractor teams early to support an accelerated acquisition and deployment schedule and to provide information to the President for his decision. The teams will develop and test their proposed versions of Brilliant Pebbles at the same time that Livermore will demonstrate the feasibility of the concept.

Figure 1 shows the concurrency between Livermore's test program and SDIO's pre-full-scale development program, including the 8-month design phase. Since these programs are scheduled concurrently, SDIO will require contractor teams to improve a design concept that will not be fully demonstrated by Livermore until near the end of their contract period. Demonstration of whether Brilliant Pebbles can find and destroy ballistic missiles and function for extended periods of time in space will not occur until later in the flight test program. These critical issues will be resolved even later than planned if Livermore's test program slips further.

Figure 1: Concurrency in the Brilliant Pebbles Program



The concurrency in the Brilliant Pebbles program occurs much earlier than the concurrency in many other Department of Defense acquisition programs. Concurrency normally occurs between the full-scale development and production phases. Brilliant Pebbles concurrency occurs before full-scale development, between Livermore's test program and pre-full-scale development. The risk is that money spent on pre-full-scale development might be wasted if Livermore fails to demonstrate that the Brilliant Pebbles concept works.

SDIO officials said that early contractor involvement increases the probability of success of Brilliant Pebbles and is essential for making it affordable and producible in large quantities.

Phase I Cost Estimate Decreased

SDIO's cost estimate for a Phase I Strategic Defense System decreased from \$69.1 billion to \$55.3 billion due to substituting Brilliant Pebbles for the Space-Based Interceptor. Table 1 shows the Phase I System cost elements that changed.

Table 1: Phase I Cost Elements That Changed

Dollars in billions

Element	Cost estimate		Change
	Oct. 1988	Oct. 1989	
Space-Based Interceptor and Brilliant Pebbles	\$18.6 ^a	\$12.0 ^b	\$-6.6
Space Surveillance and Tracking System	9.2	5.0	-4.2
Ground-Based Surveillance and Tracking System	3.3	3.8	0.5
Launch	8.6	5.3	-3.3
Performance reserve	1.1	0.0	-1.1

^aThis estimate is SDIO's original estimate of \$17.7 billion plus corrections that GAO identified in a prior classified report.

^bThis estimate is for Brilliant Pebbles.

The estimated cost of Brilliant Pebbles is less than the Space-Based Interceptor primarily because the lifejacket that will house Brilliant Pebbles interceptors in space is less costly than what would have housed the Space-Based Interceptors and most of the money for risk (cost increases) was eliminated. SDIO projects that a Brilliant Pebbles interceptor can be produced for less than half that of a Space-Based Interceptor.

Because Brilliant Pebbles does not need information from the Space Surveillance and Tracking System, SDIO decreased the number of satellites. Additional Ground-Based Surveillance and Tracking Systems were added to Phase I to make up for the change in role of the Space Surveillance and Tracking System.

Launch costs decreased primarily because the launch weight of the Brilliant Pebbles system is about 50 percent less than that of the Space-Based Interceptor system.

The performance reserve for buying additional quantities of system elements was eliminated.

MATTER FOR CONGRESSIONAL CONSIDERATION

In July 1990 GAO recommended that the Secretary of Defense advise the President to defer the decision to deploy any element of the Phase I System because of the unstable architecture and lack of integrated system-level tests. As of November 5, 1990, the Department of Defense had not formally responded to this recommendation.

GAO's review of the Brilliant Pebbles element of the Phase I System has reinforced its concerns about the President making a deployment decision by the summer of 1993. This decision date has resulted in beginning Brilliant Pebbles pre-full-scale development before the concept has been demonstrated. Therefore, the Congress should consider whether the decision on full-scale development and deployment for a Phase I Strategic Defense System by the summer of 1993 is justified by national security concerns. If the Congress determines that the summer 1993 decision date is not justified, it should direct the Department of Defense not to fund pre-full-scale development until Livermore's flight test program has adequately demonstrated the feasibility of the Brilliant Pebbles concept.

AGENCY COMMENTS

As requested, GAO did not obtain official agency comments on this report. However, GAO discussed the information in this report with SDIO officials and incorporated their comments where appropriate.

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ABBREVIATIONS

GAO	General Accounting Office
GSTS	Ground-Based Surveillance and Tracking System
SDIO	Strategic Defense Initiative Organization
SSTS	Space Surveillance and Tracking System

CHAPTER 1

INTRODUCTION

The Strategic Defense Initiative Organization (SDIO) is developing the technology for a Phase I Strategic Defense System. The goal of Phase I is to help deter a ballistic missile attack by reducing the Soviet Union's confidence that it could destroy U.S. retaliatory capabilities in the initial phase of an attack. A main element of Phase I is Brilliant Pebbles, a space-based weapon system.

ROLE OF BRILLIANT PEBBLES IN THE PHASE I STRATEGIC DEFENSE SYSTEM

In June 1987 SDIO asked the Defense Acquisition Board to approve entering the demonstration and validation phase for six elements of Phase I. This request was approved by the Secretary of Defense in September 1987. Subsequently, SDIO determined that a ground-based radar would be added to Phase I. In the summer of 1989, SDIO initiated studies to identify the best space-based weapon concept, and in February 1990 SDIO announced that one of the original elements, the Space-Based Interceptor, would be replaced by Brilliant Pebbles. The Defense Acquisition Board reviewed and approved this change and the Brilliant Pebbles acquisition strategy in June 1990.

The Brilliant Pebbles concept consists of several thousand interceptors orbiting the earth with the capability to detect and destroy targets by smashing into them at high speed. Each interceptor is to be housed in a lifejacket that will provide, among other things, communications and the necessary on-orbit protection. SDIO has sponsored research related to the Brilliant Pebbles concept at Lawrence Livermore National Laboratory since 1986, and Livermore formally proposed the concept to SDIO in late 1987.

The Space-Based Interceptor and Brilliant Pebbles concepts are significantly different. In October 1988 SDIO estimated that the Space-Based Interceptor concept would have had a number of orbiting carrier vehicles, each containing 10 interceptors. In February 1990 the Director of SDIO said that each Brilliant Pebbles interceptor would be housed in its own lifejacket. Brilliant Pebbles is expected to be less costly and more effective than the Space-Based Interceptor because it is smaller, more autonomous, and more survivable. The Space-Based Interceptor would not have been as widely dispersed and would have had to rely on other satellites for tracking, targeting, and communications.

In 1989 the President directed the Secretary of Defense to conduct a research and technology program that would provide information so he could make an informed decision within 4 years on deployment of strategic defenses. The President referred

specifically to Brilliant Pebbles as a promising concept for effective boost-phase defense that should be given particular emphasis on an expedited basis. The Secretary of Defense was to ensure that this investigation would be limited only by the pace of technical progress rather than by funding.

In July 1990 we reported that SDIO will not be able to provide sufficient information to the President to support an informed decision in the summer of 1993 to deploy the Phase I System because sufficient testing and evaluation of the Phase I System will not have been done.¹ This report deals with only one element of the Phase I System, Brilliant Pebbles, and provides additional details about the likelihood of providing only limited test information to the President to make an informed full-scale development and deployment decision in the summer of 1993.

OBJECTIVES, SCOPE, AND METHODOLOGY

The Chairman, Legislation and National Security Subcommittee, House Committee on Government Operations, requested that we review SDIO's Brilliant Pebbles program. Our objective was to review the status, schedule, and cost estimates of the program.

To determine the status of the program and the reasonableness of the schedule, we met with officials from SDIO, Lawrence Livermore National Laboratory program management, the Air Force, and the defense community. We examined test plans and various studies of the Brilliant Pebbles program to develop information about the critical issues that SDIO must address before entering full-scale development in fiscal year 1993. We also examined SDIO's cost estimate for Brilliant Pebbles to determine the basis for the \$14 billion cost estimate reduction. We did not evaluate the extent to which redundancy in SDIO's current test plan might allow objectives to be met with fewer tests.

We conducted our work from June 1989 through August 1990 in accordance with generally accepted government auditing standards. We did not obtain written agency comments on this report. However, we discussed the information in a draft of this report with SDIO and Livermore program officials and incorporated their comments where appropriate.

¹Strategic Defense System: Stable Design and Adequate Testing Must Precede Decision to Deploy (GAO/IMTEC-90-61, July 6, 1990).

CHAPTER 2

DEPLOYMENT DECISION TO BE MADE IN 1993 HAS RESULTED IN HIGHLY CONCURRENT PROGRAM

SDIO is pursuing a highly concurrent development strategy for Brilliant Pebbles to support the President's decision by the summer of 1993 on full-scale development and deployment of the Phase I Strategic Defense System. This deadline requires Livermore to rapidly conduct the tests necessary to demonstrate that the Brilliant Pebbles concept will work.

SDIO has begun a pre-full-scale development program concurrent with Livermore's test program to support an accelerated acquisition and deployment schedule. Both programs are part of the demonstration and validation phase, which precedes full-scale development. Although this degree of concurrency helps meet the accelerated acquisition schedule, it increases the risk that if Livermore's test program does not prove that Brilliant Pebbles will work, funds spent on the pre-full-scale development work may be wasted.

THE PRESIDENT DIRECTED THE DEPARTMENT OF DEFENSE TO PROVIDE THE BASIS FOR A DEPLOYMENT DECISION BY THE SUMMER OF 1993

The President directed the Secretary of Defense in 1989 to conduct the Strategic Defense Initiative in a manner that would permit him to make an informed decision within 4 years on deployment of strategic defenses.

We requested a meeting with the National Security Council to obtain more information about the reasons that led to establishing the President's decision date. We were told that our request had been referred to the Department of Justice because of legal issues it raised and that the National Security Council would respond to our request after it received advice from the Department of Justice. We had not heard from the National Security Council at the time we completed our review.

LIVERMORE'S TEST PROGRAM IS NOT LIKELY TO BE COMPLETED BY THE SUMMER OF 1993

To provide the President with necessary information, SDIO established an ambitious test program for Brilliant Pebbles designed to support the President's decision on full-scale development by the summer of 1993. However, Livermore's test program has already slipped 10 months, and the first flight test did not achieve all of SDIO's objectives. The program could slip even further because the current test schedule is

compressed, assumes no major problems or failures that cause delays will occur, and is highly dependent on adequate and timely funding.

The current test program will not be completed before the President's decision date if it slips an additional 4 months. To deal with this possibility, SDIO officials said they would consider scaling back the current test objectives or reducing the number of planned flight tests to stay on schedule. Reducing the number of tests, however, would increase the risk that test objectives would not be met.

Livermore's Test Program Will Demonstrate Brilliant Pebbles Feasibility

A primary objective of Livermore's test program is to demonstrate the technical feasibility of the Brilliant Pebbles concept. The space-based element of the concept includes two major pieces of hardware: an interceptor to destroy ballistic missiles and a lifejacket that houses the interceptor in space until it is launched at a target. The technical feasibility will be demonstrated through a series of flight tests and underground tests. These tests are augmented by pre-flight and other supporting ground tests, which will continue throughout the test program.

The three underground tests are designed to show that the hardware used in the Brilliant Pebbles test program can survive and function in a nuclear explosion environment. According to Livermore program officials, two of the three tests have already occurred.

Initial Test Schedule and Goals Were Not Met

The first flight test, originally scheduled for April 1990, was delayed. Livermore program officials attributed the delay to an ambitious test schedule and several unanticipated software and hardware integration problems. The test was rescheduled for July 1990 but, according to SDIO and Livermore program officials, was canceled a few minutes before launch because electronic hardware was damaged during an electrical storm. The test occurred on August 25, 1990. SDIO officials said that the first flight test did not achieve all its objectives due to a mechanical failure that occurred during rocket separation.

Various factors have already caused SDIO to delay each flight test phase. Some of the problems that caused the schedule to slip included the delay of the first flight test and insufficient funding allocations in fiscal year 1990 to support the original schedule.

Further Schedule Slippage Is Likely

Even though the flight test program has slipped 10 months, additional schedule slippage seems likely because the current schedule is still compressed, assumes no major problems or failures that cause delays will occur, and is highly dependent on adequate and timely funding.

Some members of the defense community agree that Livermore's test schedule will slip. A representative of the Defense Science Board told us that Livermore's concept might take longer than planned to develop because the concept is new. SDIO's System Engineer also said that the engineering and integration requirements are demanding and likely to cause the schedule to slip.

Livermore's Test Program Is Compressed

The test plan for Brilliant Pebbles states it is imperative to demonstrate the concept's technical feasibility as soon as possible to enable national authorities to make informed decisions based on technical and operational merit. SDIO has therefore directed Livermore to execute increasingly complex flight tests within a relatively short period of time.

The current schedule cannot be compressed any further. The Livermore program test manager said each phase of the current program was scheduled at the earliest possible date. We were told that Phase 1 could not be further compressed because the Livermore staff has been working at its maximum time, working space, and management resources. Also, phase 2 cannot be compressed further unless the number of tests is reduced or the test objectives are changed. Livermore program officials said phases 3 and 4 might be compressed. Phase 3 might begin sooner if earlier versions of hardware are used, funding is increased, or the contractors to be hired to conduct these phases take a different approach or use different resources or expertise.

Schedule Depends on Timely and Successful Tests

Livermore's flight test program is experimental; therefore, some problems may occur, as in the first flight test. However, it appears the tests, as currently planned, have been scheduled at intervals that are realistic only if the preceding tests are timely and basically successful. The schedule will slip further if test hardware is not ready on schedule or if basic test objectives are not met. SDIO and Livermore program officials agree that the schedule is success-oriented but believe the test program can be adjusted to accommodate some test slippage.

A test may not occur as scheduled because the test hardware is not ready. Test phases 1 through 3 use an increasingly complex version of the Brilliant Pebbles vehicle with increasingly sophisticated hardware, some of which has not yet been fully developed.

Additionally, software is still needed for test phases 2 through 4. Although Livermore program officials believe they have resolved all the challenging theoretical issues pertaining to software requirements, numerous lines of code remain to be written and tested. Moreover, this software cannot be fully tested until the hardware has been developed, integrated, and flown in space. The first flight test was delayed in part because of software and hardware integration problems.

The schedule will be adversely affected if problems occur in other areas as well. According to Livermore program officials, the availability of the test range could cause test delays, as occurred for the first flight test, as well as availability of launch vehicles.

Even if the tests occur on time, SDIO officials recognize that failure to achieve basic test objectives can affect the schedule, depending on the nature and cause of that failure. They believe that not understanding the cause of the failure would probably have the greatest effect on the schedule. Failures that require additional flight tests are also likely to affect the schedule.

At a minimum, failure to achieve critical test objectives must be understood and resolved and the appropriate lessons incorporated into the next test.² This is particularly important for the phase 3 flight tests because they are much more expensive than phase 1 and 2 flight tests. Phase 3 flight tests are more expensive because the tests will take place at the remote Kwajalein missile test range in the Pacific and the test hardware is more expensive.

SDIO and Livermore program officials agreed that the current schedule is ambitious and assumes that each test will be successful but stated that success of the program depends on meeting test objectives, not on conducting a specified number of flight tests. SDIO officials also stated that some redundancy has been built into each test phase and they would consider canceling tests if test objectives were met by prior tests. We did not evaluate SDIO's statement that redundancy may allow test objectives to be met even if tests are canceled.

²On October 5, 1990, an SDIO official said that test 2 had been delayed so that SDIO could complete a thorough check of the test and launch vehicle systems and subsystems.

Schedule Depends on Adequate
and Timely Funding

Livermore program officials said funding allocations in fiscal years 1989 and 1990 did not support the original schedule. Livermore program officials said they requested \$60 million in fiscal year 1989 but received about \$46 million. They said this allocation prevented Livermore from initiating contracts early and from buying enough test units from multiple sources to reduce the risk of schedule slippage.

For fiscal year 1990, Livermore program officials said they needed about \$130 million but received \$109 million. They said fiscal year 1990 funding allocations caused them to cancel, limit, or delay many contracts for test units and items with long lead times needed for tests in phases 2 and 3. They said fiscal year 1989 and 1990 funding allocations caused phase 2 and 3 tests to be delayed by 3 to 4 months.

The current schedule appears unlikely to be met, given SDIO's planned fiscal year 1991 funding levels.

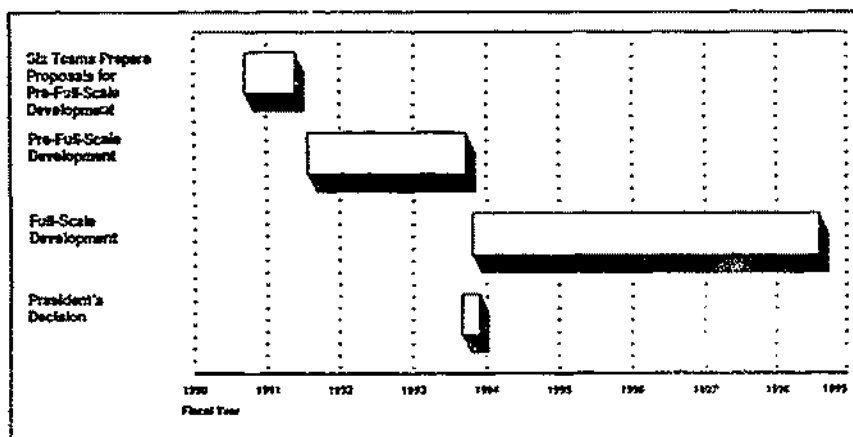
PRE-FULL-SCALE DEVELOPMENT IS CONCURRENT
WITH LIVERMORE'S TEST PROGRAM

SDIO's pre-full-scale development program is highly concurrent with Livermore's test program. According to SDIO officials, the potential benefit of the concurrency is that SDIO can pursue an accelerated acquisition and deployment schedule and provide information to the President for the full-scale development decision. However, since these programs are being conducted concurrently, SDIO will be paying contractors to improve Livermore's design concept before Livermore has demonstrated that the concept will work, which is potentially a costly acquisition approach.

Pre-Full-Scale Development Program
Supports Accelerated Schedule

According to SDIO, the purpose of pre-full-scale development is to involve teams of contractors early to support an accelerated acquisition and deployment schedule. The contractor teams will develop and test their proposed versions of Brilliant Pebbles at the same time that Livermore will demonstrate the feasibility of the concept. Figure 2.1 shows the steps in SDIO's acquisition strategy.

Figure 2.1: Brilliant Pebbles Acquisition Strategy



SDIO officials said that early contractor involvement increases the probability that the Brilliant Pebbles program will be successful. Other benefits of early contractor involvement are that technology can be transferred from Livermore to the contractors and that the contractors can provide insight to the testing process. According to SDIO, early contractor involvement is essential to meet the challenge of making Brilliant Pebbles both affordable and producible in large quantities.

The concurrency in this program occurs much earlier than the concurrency in many other Department of Defense acquisition programs. Concurrency occurs normally between the full-scale development and production phases. Brilliant Pebbles concurrency occurs before full-scale development, between Livermore's test program and pre-full-scale development. The benefit of this concurrency is that SDIO can pursue an accelerated acquisition and deployment schedule. The risk is that money spent on pre-full-scale development may be wasted if Livermore fails to demonstrate that its Brilliant Pebbles concept works.

SDIO implemented the first step in its Brilliant Pebbles acquisition strategy in May 1990 when contracts valued at about \$2 million each were awarded to six contractor teams, for a total of roughly \$12 million. Between June 1990 and February 1991, the teams are to prepare proposals that include preliminary designs, life-cycle cost analyses, test schedules, and plans to execute the various manufacturing, development, and production phases. The contractors must also demonstrate to SDIO that they can provide the manufacturing processes needed to produce

thousands of low-cost Brilliant Pebbles. SDIO refers to this part of its acquisition strategy as concept definition.³

SDIO will evaluate the six contractor proposals. It plans to award two contracts in April 1991 for the best two proposals. The winning contractor teams will have about 30 months to competitively design, build, and flight test their versions of Brilliant Pebbles.⁴ They will conduct flight tests, ground tests, and underground nuclear tests to prove the feasibility of their designs. They will also have access to data from all of Livermore's completed tests to assist them in developing their designs.

If the decision is made to proceed with full-scale development, the two contractor teams will continue into the full-scale development and production phases. They will develop a single design for the low-rate initial production decision in mid-1995. At the end of full-scale development in about mid-1998, both contractor teams will be awarded contracts for the production of the final Brilliant Pebbles system. SDIO believes that the overall production capacity of two contractor teams will reduce the risk of schedule slippage during the production phase.

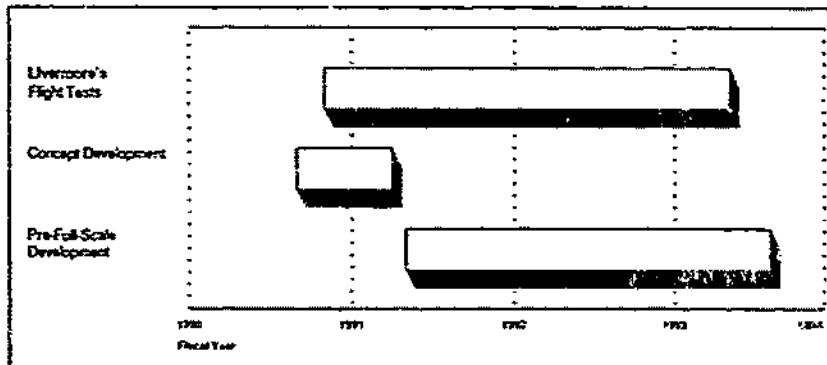
Contractors Will Be Developing and Testing Their
Designs Before Livermore Has Fully Demonstrated
That Brilliant Pebbles Technology Will Work

Since pre-full-scale development and Livermore's test program are being conducted concurrently, the contractor teams will be improving a design concept that will not be fully demonstrated by Livermore until the last flight tests, which are near the end of the pre-full-scale development contract period. Moreover, these critical tests may occur later than planned, given the probable slippage in Livermore's test program. Contractors must ensure that their designs are supported by Livermore's test results throughout pre-full-scale development. Figure 2.2 shows that the schedules for the contractor teams and Livermore's test program will be concurrent for over 2 years.

³We refer to the entire effort, including the 8-month concept definition phase, as pre-full-scale development.

⁴The exact duration of the pre-full-scale development contracts will not be decided until SDIO reviews the proposals at the end of the 8-month concept definition phase.

Figure 2.2: Concurrency in the Brilliant Pebbles Program



The ability of Brilliant Pebbles to intercept targets that are similar to intercontinental ballistic missiles will not be demonstrated until flight tests that are currently scheduled between November 1991 and May 1992. These tests are important because they involve intercepting realistic targets at realistic speeds. The ability to intercept these types of targets is essential in proving the feasibility of the Brilliant Pebbles concept; therefore, it will be important for pre-full-scale development contractors to incorporate the results of these tests into their designs. The lifejacket will also be tested in space. SDIO's test plan states that other critical technical issues are addressed in the three underground nuclear tests. Two of these tests have already occurred, and the goals of these tests have been successfully completed, according to SDIO.

CONCLUSIONS

The President established a decision date on the deployment of a Phase I Strategic Defense System of not later than the summer of 1993. This resulted in SDIO implementing a highly concurrent program that involves contracting with two contractor teams to develop and test designs for a weapon system at the same time that flight tests are being conducted by Livermore to obtain essential data demonstrating the concept. Under the current schedule, the contractors will already be more than halfway through their contract period before flight tests have shown that Brilliant Pebbles can intercept realistic targets and before orbital tests have demonstrated the performance of the lifejacket in space.

Livermore's flight test schedule is compressed, assumes no major problems or failures that cause delays will occur, and is highly dependent on adequate and timely funding. Therefore, the flight tests may take longer than planned. If the current test schedule slips more than 4 months, pre-full-scale development will be finished before Livermore's test program, and the President will either have to defer the decision or base it on limited information available at that time.

On November 2, 1990, an SDIO official told us that SDIO is reviewing options for restructuring the Brilliant Pebbles program and that the revised program will probably be significantly different from the current program.

MATTER FOR CONGRESSIONAL CONSIDERATION

In July 1990 we recommended⁵ that the Secretary of Defense advise the President to defer the decision to deploy any element of the Phase I System because of the unstable architecture and lack of integrated system-level tests. As of November 5, 1990, the Department of Defense had not formally responded to this recommendation.

Our review of the Brilliant Pebbles element of the Phase I System has reinforced our concerns about the President making a deployment decision by the summer of 1993. This decision date has resulted in beginning Brilliant Pebbles pre-full-scale development before the concept has been demonstrated. Therefore, the Congress should consider whether the decision on full-scale development and deployment for the Phase I Strategic Defense System in the summer of 1993 is justified by national security concerns. If the Congress determines that the summer 1993 decision date is not justified, it should direct the Department of Defense not to fund pre-full-scale development until Livermore's flight test program has adequately demonstrated the feasibility of the Brilliant Pebbles concept.

⁵See footnote 1.

CHAPTER 3

ESTIMATED COST OF PHASE I STRATEGIC DEFENSE SYSTEM DECREASED DUE TO USING BRILLIANT PEBBLES

The change to Brilliant Pebbles lowered SDIO's cost estimate for the Phase I Strategic Defense System by \$13.8 billion, from \$69.1 billion to \$55.3 billion.⁶ The substitution of Brilliant Pebbles for the Space-Based Interceptor accounts for about half of the reduction. The remainder was due to changes in the Space Surveillance and Tracking System, Ground-Based Surveillance and Tracking System, launch costs, and the performance reserve.

SDIO's new estimate of \$55.3 billion represents only a snapshot at a point in time that is very early in the development cycle of the Phase I Strategic Defense System. Department of Defense experience has shown that such early estimates usually increase for various reasons.

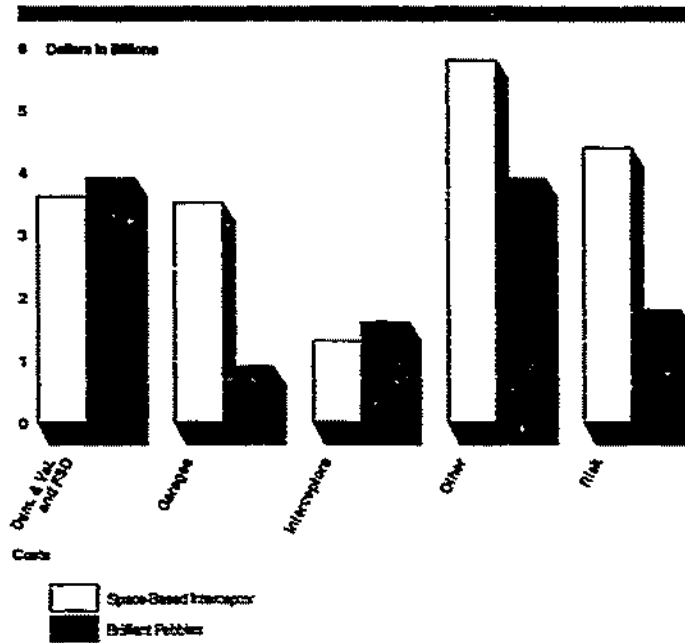
BRILLIANT PEBBLES IS ESTIMATED TO COST LESS THAN THE SPACE-BASED INTERCEPTOR

As a result of switching from the Space-Based Interceptor to Brilliant Pebbles, the estimated cost for developing and producing a space-based kinetic kill missile system decreased from \$18.6 billion⁷ to \$12 billion, a reduction of \$6.6 billion or 35 percent. Figure 3.1 and table 3.1 compare the major cost categories of these two estimates.

⁶All dollar amounts are in fiscal year 1988 dollars.

⁷This represents SDIO's original estimate of \$17.7 billion plus corrections we identified in a prior classified report, which increased the estimate to \$18.6 billion.

Figure 3.1: Comparison of Space-Based Interceptor and Brilliant Pebbles Costs



Note: Dem. & Val., demonstration and validation; FSD, full-scale development.

Table 3.1: Comparison of Space-Based Interceptor and Brilliant Pebbles Costs

Dollars in billions

	Research and development	Production			
		Garages	Interceptors	Other	Risk
Space-Based Interceptor	\$3.6	\$3.5	\$1.3	\$5.8	\$4.4
Brilliant Pebbles	3.9	0.9	1.6	3.9	1.8

Comparison of Research and Development Cost Estimates

The estimated cost for research and development, which includes the demonstration and validation phase and the full-scale development phase, increased from \$3.6 billion for the Space-Based Interceptor to \$3.9 billion for Brilliant Pebbles.

Comparison of Production Cost Estimates

The production cost estimates had four major cost categories: garages, interceptors, other, and risk. Although the total production cost for interceptors increased, the average unit production cost for each Brilliant Pebbles interceptor was less than one-half of that for a Space-Based Interceptor.

Garages

Each interceptor is housed in a garage until launched. The garage for the Space-Based Interceptor was called a carrier vehicle, and each would have housed 10 interceptors. The garage for Brilliant Pebbles is called a lifejacket, and each will house one interceptor.

The change from the relatively expensive and heavy Space-Based Interceptor carrier vehicle with the less expensive and lighter Brilliant Pebbles lifejacket was a major reason for the decreased cost. The change resulted in a substantial reduction in manufacturing cost of garages. Reductions in estimated costs occurred in six of the seven major subsystems.

The average unit cost to house one Brilliant Pebbles interceptor was less than one-fourth of that for one Space-Based Interceptor.

Interceptors

The estimated average unit manufacturing cost of an interceptor decreased substantially. The reduction resulted from cost decreases for many of the major components, including the sensor, guidance, data processing, and power subsystems. Only the communication subsystem increased.

Other

Other reductions occurred in several procurement-related cost categories included in the other category. The total for the other category decreased nearly \$2 billion, from \$5.8 billion for Space-Based Interceptor to \$3.9 billion for Brilliant Pebbles.

The estimates for facilities integration, project management, and procurement contract fees accounted for a reduction of \$2.2 billion. The reduction was offset by an

increase of \$227 million for testing and other, resulting in a net reduction of \$2 billion.

Risk

The Space-Based Interceptor estimate for risk and engineering changes for the production phase was \$4.4 billion. The Brilliant Pebbles estimate was \$1.8 billion, a substantial reduction.

SWITCH TO BRILLIANT PEBBLES AFFECTS OTHER PHASE I COSTS

The switch to Brilliant Pebbles resulted in a net decrease of \$8.1 billion in the estimated cost of four other Phase I Strategic Defense System cost elements: the Space-Based Surveillance and Tracking System decreased \$4.2 billion, the Ground-Based Surveillance and Tracking System increased \$500 million, launch costs decreased \$3.3 billion, and the \$1.1 billion performance reserve was eliminated.

Space Surveillance and Tracking System Cost Changes

The estimated cost of the Space Surveillance and Tracking System (SSTS) decreased 46 percent, from \$9.2 billion to \$5 billion. The decrease is attributed to changes in the function SSTS is expected to perform in the Phase I Strategic Defense System. According to SDIO, the role of SSTS changed considerably with the substitution of Brilliant Pebbles for the Space-Based Interceptor.

In the October 1988 Space-Based Interceptor architecture, SSTS's role was to provide information to the Space-Based Interceptor. Its primary mission was to track targets and support weapon engagement. The SSTS satellites were to provide weapon target assignment, fire control, and in-flight updates for the Space-Based Interceptor and Ground-Based Interceptor systems during the post-boost and early midcourse phases. The SSTS track data would also be used to cue Ground-Based Surveillance and Tracking System and the Ground-Based Radar.

In the October 1989 Brilliant Pebbles architecture, SSTS's mission was redefined. It will now be used for surveillance and data collection.

Ground-Based Surveillance and Tracking System Cost Changes

The Ground Based Surveillance and Tracking System (GSTS) is a ground-based, rocket-launched sensor system. It functions only during the engagement state;

otherwise, it remains in the alert condition. It will be deployed at sites colocated with Ground-Based Interceptors.

SDIO's October 1989 estimate increased 15 percent from its October 1988 estimate, primarily due to increasing the number of systems. The additional systems were a result of switching from SSTS to GSTS for resolution and cluster tracking in the midcourse phase.

Launch Cost Changes

The Phase I launch cost estimate decreased \$3.26 billion between October 1988 and October 1989, as shown in table 3.2.

Table 3.2: Phase I Launch Cost Changes

Dollars in billions

<u>Element</u>	<u>Cost estimates</u>		<u>Change</u>	
	<u>Oct. 1988</u>	<u>Oct. 1989</u>	<u>Amount</u>	<u>Percent</u>
Boost Surveillance and Tracking System	\$1.80	\$2.00	\$0.20	10
Space Surveillance and Tracking System	1.40	0.60	-0.80	-57
Space-Based Interceptor and Brilliant Pebbles	<u>5.36</u>	<u>2.70</u>	<u>-2.66</u>	-50
Total	<u>\$9.56</u>	<u>\$5.30</u>	<u>-\$3.26</u>	-38

The Boost Surveillance and Tracking System constellation size, mission, and technical characteristics did not change. However, its estimated launch cost increased 10 percent. SDIO could not explain this increase.

The number of SSTS satellites to be launched decreased. This reduced the launch costs by 57 percent, from \$1.4 billion to \$0.6 billion.

In October 1988 SDIO estimated the Space-Based Interceptor's launch cost at \$5.36 billion. It based the cost estimate on the assumption that a modified Peacekeeper missile would be used to deploy the system. In October 1989 SDIO estimated the launch cost at \$2.7 billion, a decrease of 50 percent. The decrease was due to a reduction of 38 percent in the number of pounds launched to orbit and a reduction of 18 percent in the cost per pound to launch Brilliant Pebbles. According to SDIO, the

launch system that will deploy Brilliant Pebbles has not yet been decided, and several launch vehicle solutions are being considered. However, to estimate the October 1989 launch cost, SDIO selected the Titan IV as the launch vehicle and Vandenberg Air Force Base in California as the launch site.

Performance Reserve Eliminated

The October 1988 cost estimate included a \$1.1 billion performance reserve to be used to procure additional quantities of Space-Based Interceptors to react to uncertainties in the projected threat. SDIO eliminated the \$1.1 billion performance reserve from its October 1989 estimate for Phase I.

MAJOR CONTRIBUTORS TO THIS REPORT

NATIONAL SECURITY AND INTERNATIONAL AFFAIRS DIVISION,
WASHINGTON, D.C.

Norman J. Rabkin, Associate Director
J. Klein Spencer, Assistant Director
Lisa Shames, Assignment Manager
John Cullen, Cost Analyst

SAN FRANCISCO REGIONAL OFFICE

Frank Graves, Evaluator-in-Charge
Michele Grgich, Evaluator
Thomas M. James, Evaluator

(392505)

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